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FUNGI PRODUCING HEART-ROT OF APPLE TREES

B. O. Dodge

(With Plates 173–176, Containing 10 Figures)

Any one familiar with the old apple orchards of the East is aware that there must be specific causes connected with the rotting of the trunks of the trees. When trees that ought to be in the prime of life are found with huge knot-holes leading into great hollows in the trunk, the pathologist feels perfectly certain that some fungus has gained entrance to the wound caused by the removal of a limb at this point.

At Camp Columbia, near Litchfield, Conn., and on the farms in the vicinity, there are many old orchards that are especially favorable for a study of diseases peculiar to the apple tree. Nature is left to take its course in the abandoned orchard, with the result that fungi directly or indirectly the cause of wood-rot are given an opportunity to develop their fruiting bodies, without which the identification of the disease is still more uncertain. Some of these trees seventy-five or one hundred years old are still bearing apples, although the trunk is a mere shell of sap-wood, frequently only a part of the shell remaining. A large percentage of the trees bear evidence of the presence of fungi commonly known as heart-rots.

I have made an effort to collect various types of fungi growing on living trees with the hope that something further might be contributed toward the discovery of the particular fungi causing these destructive heart-rots. I was greatly assisted in this work of collecting and photographing the specimens by Mr. Paddock, a student in botany at the camp.

The well-known rots of hickory, oak, maple, elm, etc., were fairly common there. A number of bracket and encrusting forms (*Polyporus versicolor, Schizophyllum commune, Irpex lacteus,* etc.) were found on dead limbs and trunks of the apple, but as these grow everywhere on all sorts of timber their presence on apple is not particularly significant as causing the diseases of the living trees. A perennial form resembling the fire punk (*Fomes igniarius*) occurs on a few apple trees just below the camp. On one of the trees the fungus has developed the fruit bodies on the cut ends of stubs of limbs, showing probably where the fungus gained entrance in years past through faulty pruning.

But all these are doubtless comparatively secondary in causing the very destructive heart-rots found in these old orchards. A number of very conspicuous and striking forms which I have found are beyond doubt the main causes which limit the life of the orchard tree. This is not saying that these fungi are directly parasitic, but by eating out the heart-wood of the tree they lead to the breaking off of the larger branches and finally to the destruction of the trunk.

During the early part of August, Mr. Moldenke first called my attention to a cluster of "mushrooms" growing on the side of a living apple tree in an orchard through which the Columbia student surveyors were "running a railroad." The fungus had grown out from a small spot in the sap-wood and the line of decay was found to lead into the heart-wood, which was very badly rotted. Figure 2 on plate 173 shows such a punk as it grows on the living tree. Professor Finch a few days later located a similar fungus on a comparatively young apple tree near the cottage at South View Inn. This one grew out from a crack caused by the splitting of the trunk where a limb had been torn out (*Pl. 173, f. 3*). It was a beautiful milk-white cluster, so fragile that the slightest pull was sufficient to break off a piece. An old punk just below this cluster, evidently a growth of the preceding year, showed how discolored, hard, and leathery the fungus may become as it dries out. Two very beautiful specimens (*Pl. 173, f. 2*, and *Pl. 174, f. 2*) were found on a tree in Mr. Weik's orchard. Several others were brought in during the middle of August from orchards in the vicinity. The specimens, while varying greatly in form and size, appear to belong to the same species. It is a form that first attracted the attention of Dr. Burt at Riverside, Maine, in 1898. He sent it to Professor Peck, New York State botanist, who recognized that it was a new species and described it in the *Bulletin of the Torrey Botanical Club,* Vol. 26, 1899, under the very appropriate name, *Polyporus admirabilis,* "the wonderful polypore." He added Dr. Burt's remarks: "The fresh tufts of clear white trumpet-shaped pilei are suggestive of clusters of giant calla lillies." Peck originally described the fungus rather inadequately because of the lack of a large number of specimens at the time. He says: "Pilei tufted, large, more or less imbricated, nearly entire, centrally depressed or subinfundibuliform." This would not cover the solitary, flattish, nearly lateral forms. Such forms are shown in *Pl. 173, f. 1.* Professor Underwood also found one of these flat forms on an apple tree at Redding, Conn., in August, 1906, and another less distinctive with much thicker flesh in 1907. These two specimens are in the herbarium of the New York Botanical Garden.

Forms frequently occur that appear from a distance to be made up of several individuals crowded together forming a "cluster." Such specimens are shown in *Pl. 173, f. 1,* on the trunk, and *Pl. 174, f. 2.* These are simply one fungus body so lobed and folded as to resemble a tuft or cluster composed of several individuals growing close together. Figure 2, on plate 174, looks like three punks (pilei), although it is only a peculiarly folded single specimen. There are, however, such clusters as Peck described made up of individuals somewhat imbricated or fused together.

Another specimen of this species mentioned by Peck (Annual Report 54, p. 154, 1901) came from Lake George. Of this one he says: "The specimen here recorded is less regular and deeply depressed in the center than a typical form which was found growing at the base of an apple tree in Maine." In the original description the surface is described as "glabrous, white or slightly tinted with pale yellow or cream color; pores minute, rotund, whitish; pilei 10–15 cm. broad, united at the base, forming tufts 30 cm. or more in diameter."

The forms that I have found at Camp Columbia are beautiful, large, vigorously growing punks, easily recognizable and conspicuous objects. One of their most characteristic features as compared with the forms of another type to be mentioned later, is the peculiar, smooth, "glacé kid glove" feeling of the surface. They justify Professor Peck's characterization *"admirabilis"* in every respect.

With the aid of Dr. House, the state botanist, I was enabled to examine all of Peck's specimens of this fungus in the herbarium at Albany. One specimen collected by S. H. Burnham on an apple tree trunk at Pike Pond, New York, July, 1910, has a margin that is beautifully and evenly scalloped. The surface is even, light-straw-colored, and has characteristically a "kid glove feeling." There are one or two faint zones near the margin formed by depression but there are no color differences. There is a slight tendency to splitting up or pileolation, there being one accessory pileus. The stem is much reduced or even lacking. There is another specimen from Crown Point, N. Y., collected by Dr. Peck, which is a cluster of three plants now in very poor condition. No host is given but it is evidently the same species.

I have found *Polyporus admirabilis* only on apple trees, but it is to be noted that there are two specimens in the State Herbarium under this name that are of special interest, since they were collected on other hosts than the apple tree. The one on ash found by S. H. Burnham at Vaughans, N. Y., July 6, 1907, and mentioned in the report for 1907, p. 12, is a dead-white form with minute pores. Two plants are joined together at their margins. The stems are quite distinct and prominent. The other specimen was collected by Mr. Burnham at the same place August 25, 1911, on a "living fallen butternut." The stem is central or slightly eccentric and more pronounced. All of these specimens are pure-white with no trace of straw-color, otherwise they resemble those growing on ash. These forms on the ash and butternut appear to be somewhat different from those on the apple tree and are certainly more like specimens of *P. Underwoodii* in Murrill's collections at the New York Botanical Garden, but whether these differences would hold in a larger range of specimens and whether the spores of these forms would grow on the apple tree, are questions of considerable interest and must be further studied. Another specimen in the Albany Herbarium, which plainly should be called *P. admirabilis,* bears the name *Polyporus Underwoodii.*

This was collected by Mr. Burnham at Pike Pond, July 23, 1910, on a fallen apple tree trunk. Just why this was called *Polyporus Underwoodii* and the one on the ash collected by the same person at the same place should be called *Polyporus admirabilis* is not clear. This specimen corresponds very well with the text description of *P. admirabilis* and to many of the forms collected at Camp Columbia. It shows distinctly the tendency both to bracketing and clustering. The margin is finely and irregularly scalloped. It has the "glacé kid finish" but is further markedly ribbed and streaked with faint zonations in form and color. The depressed, funnel-shaped disk is somewhat flesh-colored. The stems are quite conspicuous, though short, but the pores extend down to the base on the under surface.

In connection with the question as to the group relationship of these forms, a specimen of "*Polyporus Underwoodii*" from the Albany collection is of considerable interest. Lloyd has evidently noted the obvious resemblance of these apple tree forms to the *Melanopus*, black stemmed, group of polypores in stating that Peck's *P. admirabilis* is a variety of *P. varius*, or belongs to that group, though he does not state that any of his specimens of the apple tree fungus show a blackening of the stem. This specimen of *P. Underwoodii* found on a willow stump to which I refer was collected by H. J. Banker at Schagticoke, N. Y., August 27, 1908. It has the general form and size of *P. admirabilis* with the irregularly scalloped margin and depressed center. The specimen is somewhat weathered and the surface is roughened and blackish-spotted. The pore characters are not different. It has a conspicuous, sterile, blackened, eccentric stem and, like a smaller specimen of the same collection, bears some resemblance to a much exaggerated and unusually thin form (for its size) of *P. varius*.

Another specimen collected by Dr. Banker August 2, 1904, and referred to by Peck in describing *P. Underwoodii* is still closer to *P. admirabilis* in appearance, but it has the black, though very short stipe. One specimen from this collection given to the New York Botanical Garden has a central stipe but otherwise resembles the 1908 specimen from the same regions. Further collections of this type of fungus with the black stem but otherwise resembling *P. admirabilis* may clear up the relation between the apple tree form and those of the *Melanopus* group, and all these relationships must be cleared up if the question of protecting the apple tree against heart-rot is to be attacked with any degree of success.

In every case where such a punk was discovered on the apple, it was found that the heart-wood was in a bad state of decay, although in some cases one would say, judging from external appearances, that the tree was perfectly sound. The pores in all of these species are very small and those of *P. admirabilis* are extremely minute. The tubes are 1–2 mm. long and the flesh varies in thickness 1–2 cm. at most toward the point of attachment. As I have noted, some of the specimens show lines or streaks extending from the margin to the central depressed region (*Pl. 174, f. 2*). The single fruit-body shown at the base of the tree in *Pl. 173, f. 1,* measured eighteen inches along its greatest diameter and weighed four and one half pounds. This is probably the largest specimen of the species yet recorded and it has been placed in the Herbarium of the New York Botanical Garden. Dr. Murrill has confirmed the identification of the species.

So far as I find, there is little in the literature relating to fungi that cause heart-rots of apple tree. Morse and Lewis of the Maine Agricultural Station describe several diseases affecting the leaves and fruit of apples and discuss briefly the wood-rots of the apple tree, but they do not ascribe the rots to any particular fungi. Craig has made extensive surveys of the apple orchards of New York and has discussed the subject of pruning as connected with the decay of trees. He does not mention having seen this fungus or any other of its kind on the living trees. The punks of this polypore are evidently either rare or have been overlooked, since there are only the half dozen specimens described above in the herbarium at Albany and two at the New York Botanical Garden. It will be interesting to learn whether a long rainy season, such as we had in July and August, 1915, is one of the conditions necessary for the production of the punks.

We found another type of fungus growing from a decayed root stub in Mr. Bennett's grove near Camp Columbia. It is a white polypore (*Pl. 174, f. 1*) three or four inches in diameter, depressed or funnel-shaped and somewhat inequilateral. The surface is radially split or cracked and somewhat lobed, and is also broken up into concentrically arranged scale-like tufts. The tubes are large and angular, running down on the stem, which is very well marked. This plant is tough from the first, about the consistency of the railroad tie fungus (*Lentinus lepideus*). It was kept under observation for about three weeks. At the time the photograph shown in *Pl. 174, f. 1,* was taken, Mr. Paddock called my attention to the spores that were being shed in little white clouds. It is possible that this is a form of *Polyporus admirabilis* that grows saprophytically on wood other than that of the apple tree. The character of the surface, the large size of the angular pores, and its place of growth, suggest more strongly, however, that it is quite another species. Dr. Murrill, who has examined this specimen, informs me that it is near *P. Underwoodii,* although it does not have a black stem as do both the specimens at Albany and as required by the description.

The apple grower is much more interested in the extent of damage that is being wrought than in controversies over the identity of the fungus causing the disease. He wants to know how to recognize the fungus, how to cure the diseased tree, and how to prevent further infection. While it is the part of wisdom to follow the most approved methods of pruning, it may be well to consider whether the ordinary precautions that are taken to coat the cut surface with paint is really of much avail in keeping out the spores of these fungi. Freezing and thawing, wetting and drying certainly will cause cracks to open up and, unless the surface is kept well painted until a callus completely covers the wound, there can be no certainty that some fungus will not gain entrance. The fungus here under consideration causing the heart-rot of apple trees could, perhaps, be more easily controlled by the destruction of the spore-producing bodies themselves, since they are large and conspicuous and easily removable.

OTHER TYPES OF PUNKS CAUSING HEART-ROT OF APPLE TREES

As I have noted previously, *P. admirabilis* belongs to the group in which the fruit-body has a stem, although it may be very much reduced. There is a series of other forms that were even more common on apple trees during the past season, which are brackets in form and are often placed one above the other and closely connected. A beautiful example of this type (*Pl. 175, f. 2*) was found August 10 on a tree in the orchard near Robert Hill's residence, a few miles from Camp Columbia. In color, size of pores, zonation and consistency of flesh, I was unable to distinguish between it and such a form of *P. admirabilis* as is shown in *pl. 173, f. 3*. The fact that the former is a shelving or bracketed punk, however, suggests that it must be an entirely different species. Further search has shown that many apple trees were infected this year with a form resembling this one. It is impossible to say what conclusion will be reached as to the number of species involved until a more extensive study of these apple tree fungi has been made. I have found similar punks in many old orchards in New York, New Jersey, and in several localities in Connecticut, and have a form collected by Professor Harper on a living apple tree at Bedford City, Va., September 16. These forms are much more abundant at Camp Columbia than *P. admirabilis*. Most commonly the base of the tree would be quite covered on one side with such punks as are shown in *Pl. 175, f. 1*. The heartwood as the result of the attack is usually very spongy or entirely decayed. The fungi are so fragile that it is difficult to cut out the bark and sap-wood bearing them without shattering the punks. The upper surface in this particular type is soft and spongy, at first somewhat "foamy" in appearance. They are sometimes quite thin at the edge, thickening further back or even becoming hoof-shaped (*Pl. 175, f. 1*). The only difference between this form and the one found at Robert Hill's appears to be the character of the upper surface and the texture of the flesh. The pores are somewhat larger and the flesh thicker in the former. Both forms were observed for several days as they were growing and these differences were quite noticeable from the first.

A somewhat different type was found by Mr. R. R. Stewart at New Rochelle, N. Y., September 21, and its pore surface is shown in *Pl. 175, f. 3*. This single specimen was growing on a living apple tree about five or six feet from the ground. It is a thin, flat form about four inches wide by six inches long, and not over half an inch thick. The tubes are about one fourth of an inch long, the flesh is zonate and about as thick as the tubes are long. The fungus was white when fresh but it turned yellowish or straw-colored on drying. We have further specimens of this type of fungus, many of them growing on the inside of the hollow trunks of the apple tree. Mr. Burgdorff called my attention to one of this kind at Scarsdale, November 17. About five feet above the ground there was a large knot-hole leading into the hollow trunk of an apple tree about seventy-five years old. Several overlapping, much divided brackets had developed inside the trunk on the decayed heartwood about a foot above the opening formed by the knot-hole. This led me to examine more closely hollow trees in different localities and, in one orchard at Spring Valley, N. Y., on November 26, we found six different trees that had the same type of fungus entirely concealed within. In all cases the color was masked by the pulverized wood, the tubes and flesh were dingy or brownish. The upper surface especially was a reddish-brown. The ones found at Spring Valley were hard and dry and had evidently reached maturity several weeks previously. On December 7, Mr. Burgdorff brought in another specimen of this same general type, although there are in this one certain peculiarities that may serve to connect up many of the forms that are found on the apple tree. It was late in the season, the fungus was in fairly good condition, and spores could be found in abundance. It was about five inches long and six inches wide, consisting of several shelving brackets grown together behind, and the flesh was beautifully zonate and at least an inch thick, thinning out toward the margin. The tubes were about one fourth of an inch in length.

Professor Harper, as noted above, found quite another type growing on an apple tree at Bedford City, Va., September 16. This form, shown on *Pl. 176,* resembles the one shown on *Pl. 175* with respect to surface markings, etc., but it is a solitary form, more hoof-shaped, and has flesh that is several inches thick and strikingly zonate. The tubes are half an inch long and very much larger than those of any other specimens previously mentioned. It is a heavy, soggy fungus, drying hard and horny. Dr. Murrill identifies this form as *Spongipellis fissilis*.

We have thus several types of the second form of fungus causing a heart-rot of the apple trees. Just what is their identity cannot be determined with certainty at present. Dr. Murrill, who has seen some of our specimens from the vicinity of New York City, identifies them as *Spongipellis galactinus*. There is a specimen at the New York Botanical Garden bearing this name collected by F. C. Stewart from a living apple tree. His field notes state: "Pure white, inside a hollow apple tree, Redding, Conn., 1907." Murrill mentions this peculiarity in a note (Bull. Torrey Club **32**: 476, 1905). He says: "One of its favorite hosts is the apple tree, on which it has several times been found in New York and Connecticut, growing inside partially decayed trunks or emerging from knot-holes in living trees. When fresh, it is pure-white or watery-white and so full of water that this may be squeezed out as from a sponge."

This is a very interesting series of forms connected with the destruction of orchards of the region. None of them has been hitherto regarded as particularly damaging to the apple tree, but there can be no question, in my opinion, that they are quite limited to the apple tree. Mr. Lloyd reports twenty collections of this second series of types, most of them from apple trees of the New England States. A few are from chestnut. He calls them *Polyporus spumeus* var. *malicolus*. Lloyd evidently recognized this form as particularly limited to the apple and mentions that they are the cause of heart-rot of apple trees of New England. Whether his identification of these forms is correct, is a question that can be determined only by further study of the group, which should, of course, include inoculation experiments.

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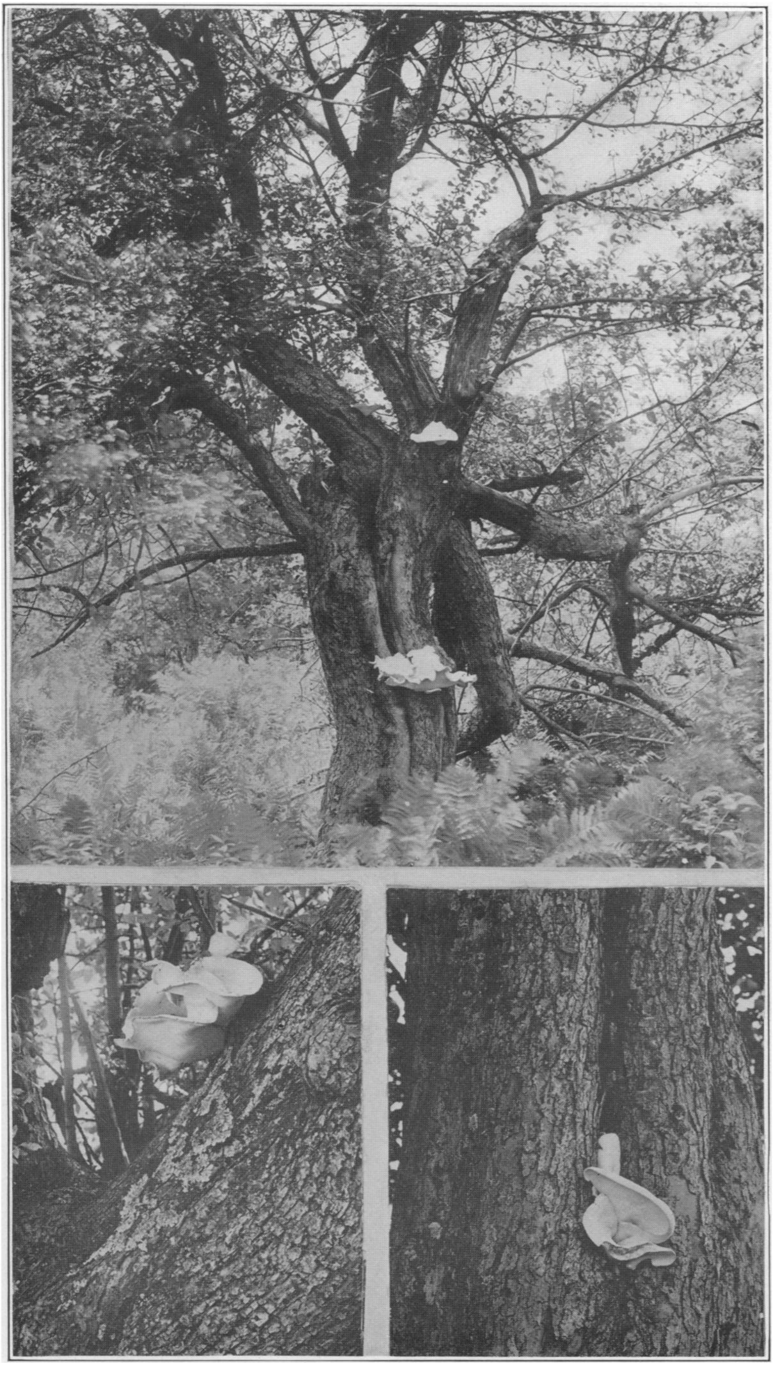
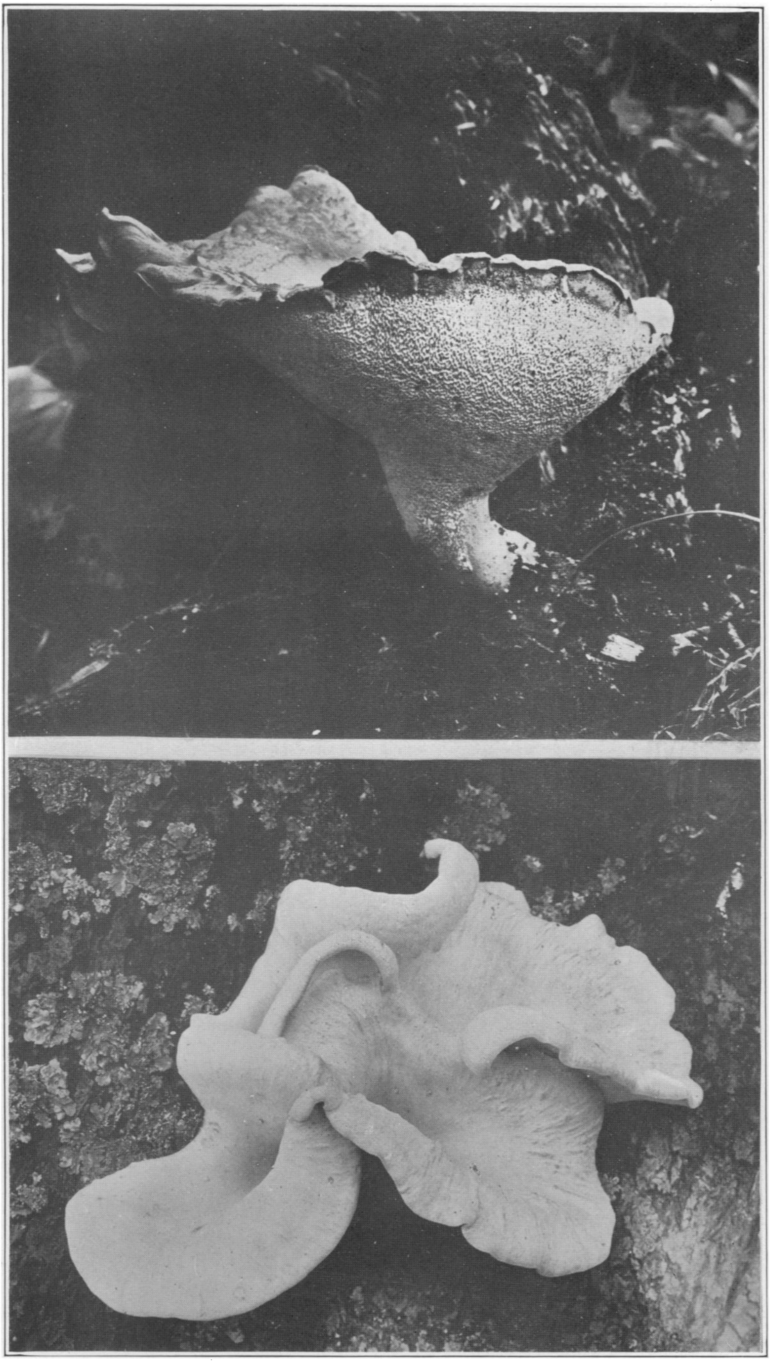


POLYPORUS ADMIRABILIS PECK



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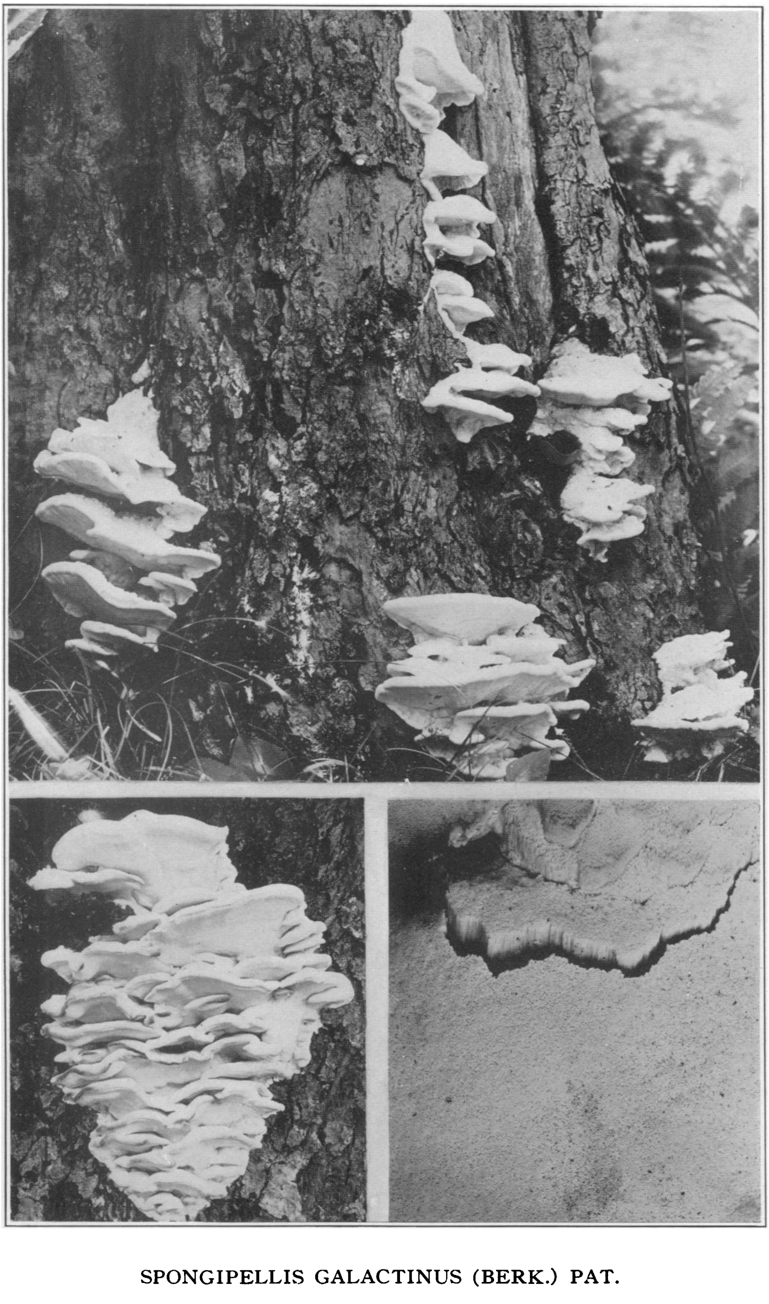
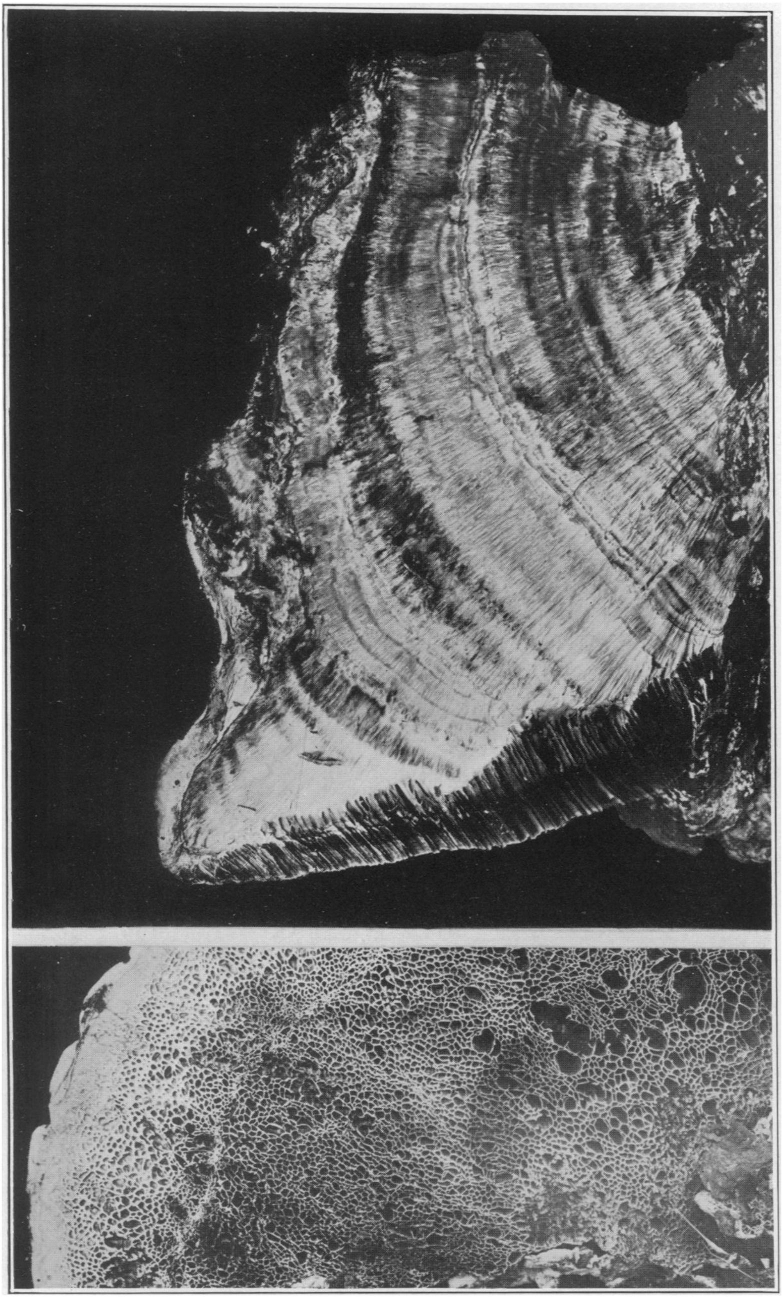


SPONGIPELLIS GALACTINUS (BERK.) PAT.



SPONGIPELLIS FISSILIS (BERK & CURT.) MURRILL

EXPLANATION OF PLATES CLXXIII–CLXXVI

All the specimens mentioned here were collected on living apple trees, with the exception of that shown on *Pl. 174, f. 1.*

PLATE CLXXIII

Fig. 1. An old apple tree that had been struck by lightning some time in the past. Three punks matured August 15, 1915. The one below on the trunk was eighteen inches across. These are good specimens of *Polyporus admirabilis.*

Fig. 2. Shows a cluster of the punks apparently growing from a healthy limb. In reality the heart-wood was decayed. Specimens now in the herbarium of the New York Botanical Garden.

Fig. 3. *Polyporus admirabilis* on a young apple tree at South View Inn.

PLATE CLXXIV

Fig. 1. A specimen of *Polyporus* near *P. Underwoodii* found on a decayed root stub in Bennett's grove.

Fig. 2. *Polyporus admirabilis* from Mr. Weik's orchard. A much folded specimen resembling a cluster of three individuals.

PLATE CLXXV

Fig. 1. These specimens have been identified by Dr. Murrill as *Spongipellis galactinus.* Would be called *Polyporus spumeus* var. *malicolus* by Mr. Lloyd.

Fig. 2. The specimen from Robert Hill's orchard near Camp Columbia has many of the characters of *P. admirabilis,* yet is plainly one of the bracket forms like those shown in Fig. 1.

Fig. 3. Pore surface from a specimen found by Mr. Stewart at New Rochelle, September 21, 1915.

PLATE CLXXVI

A form found by Professor Harper on living apple tree at Bedford City, Virginia, September 16, 1915, identified by Dr. Murrill as *Spongipellis fissilis.*

Fig. 1. Shows the thick flesh, which is beautifully zonate, the long tubes, and rough surface.

Fig. 2. View of the pore surface.